



INDUSTRY 8 SEMINAR 5

E M E A

The **Power** of **Data**



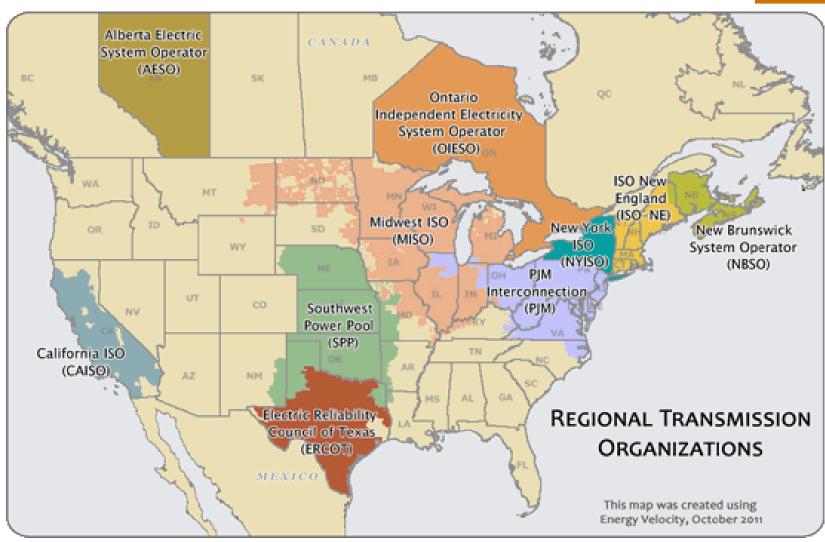


PJM Advanced Control Center Visualization, Analytics and Smart Grid

Presented by **Tom Keyser PJM Transmission System Operator**

Regional Transmission Organizations





PJM Territory





PJM History



- Founded in 1927, PJM Interconnection is an independent and impartial organization that manages the transmission system and operates the wholesale electricity market.
- Valley Forge, PA.
- Three original members were utilities from Pennsylvania (P), Jersey (J), and Maryland (M) – thus PJM.
- 802 members: transmission owners, generation owners, electric distributors.

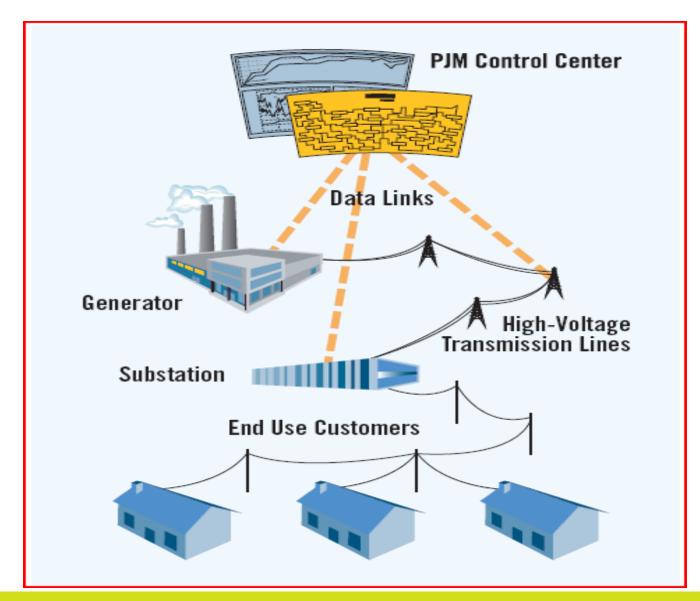
PJM Overview



- PJM is a Regional Transmission Organization (RTO)
 - Coordinates the movement of wholesale electricity in all or parts of 13 states and Washington D.C.
 - Operates wholesale electricity market
 - Manages the high-voltage electricity grid to ensure reliability for more than 60 million people
 - Peak Demand is ~163,000 MW
 - Peak Capacity is ~185,000 MW
 - PJM territory includes 6,000 substations
 - 62,000 miles of transmission lines (69KV-765KV)
 - Over 1,200 Generators

PJM Control Center





Control Room Staffing



- Two fully operational control rooms
- Work load divided between the two control rooms
- 4 Transmission Dispatchers
- 2 Generation Dispatchers
- 1 Reliability Engineer
- 1 Load Forecaster / Generation Scheduler
- 1 Shift Supervisor

EMS and Market System



- Siemens Spectrum EMS-Monitor Transmission System
 - 2 fully redundant EMS systems
 - Transmission and Generators send data to both EMS
 - One EMS used to control the system, other on Hot standby
 - Transmission/Generation companies provide ICCP links to each EMS
 - Monitor over 6500 contingencies
 - State Estimator runs every 60 seconds
 - Security Analysis runs every 2 minutes
- Alstom-Energy Market and Ancillary Services
 - Run a Security Constrained Economic Dispatch
 - Day ahead and real-time market

PJM PI System



- PJM has a site license with OSIsoft
 - Currently use over 1Million tags
 - By the end of 2012, SE and SA data will be added to PI which will add hundreds of thousands of new tags.
 - 28 Production Servers
 - 6 Dispatch Training Servers-EMS Simulator
 - 22 Test Servers
 - 9 Stage Servers

System Overview



- This year PJM upgraded to PI Server 2010
- Installed PI AF, but don't have a full model yet
- PJM uses PI ACE (Advanced Computing Engine) for Calculation and Analytics
- PI Web Services
- Synchrophasor Data
 - Currently collecting data from 65 PMUs
 - 1300 raw C37.118 data stream PI tags
 - 400 Calculated tags (PI ACE)
 - Ramping up to a total of 129 PMUs

PI Client Overview



- OSIsoft WebParts in Microsoft SharePoint web environment to share data with NERC (North American Electric Reliability Corporation) and FERC(Federal Energy Regulatory Commission)
- PI ProcessBook displays for dispatcher real-time monitoring, training and during simulations and restoration drills
- PI ProcessBook displays for after event analysis
- PI DataLink (in Excel) for engineering analysis and reporting

Data Collected in PI System



- Voltages for Buses from 34kv-765kv
- MW and MVAR values for all generation units greater than 1 MW
- MW and MVAR values for transmission facilities 69kv-765kv
- Transformer load tap change positions
- MVAR values for synchronous condensers
- Generation station frequencies
- Circuit Breaker and switch statuses
- LMPs (Locational Marginal Pricing), unit data (min, max and base point, etc.)

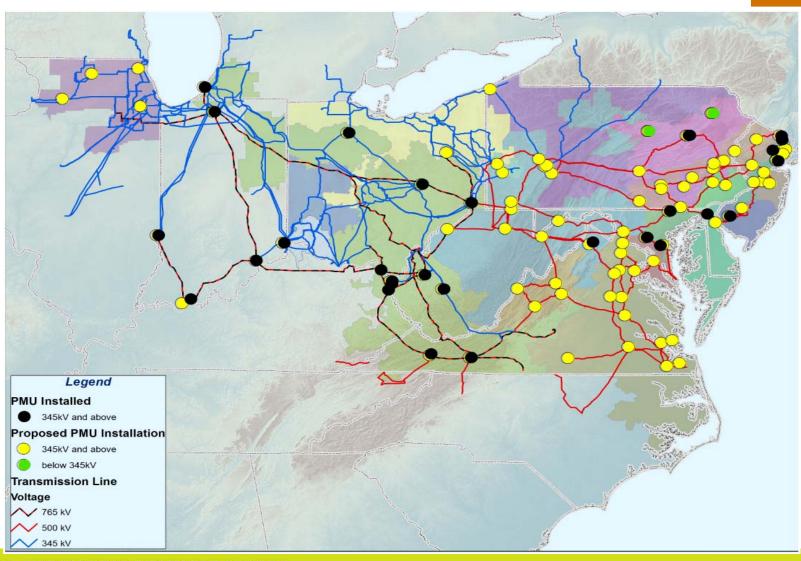
Synchrophasor Data



- 360 PMUs installed in 90 substations by 2013
- Covering 10 states
- Total of 720 Measurements from all PMUs
- 4096 bytes per PMU Message
- 30 Messages per second 1.2MB per second of data
- Each PMU generates 108,000 database rows per hour
- Estimated 1TB data per month collected
- 1,302,528 bytes of data, per second streaming from the PMUs to PJM
- 17 Phasor Data Concentrators to be deployed
- PJM will also collect phasor data from roughly 150 substations external to PJM

PMU Deployment





SCADA to Phasor Measurements From X-Rays to MRIs

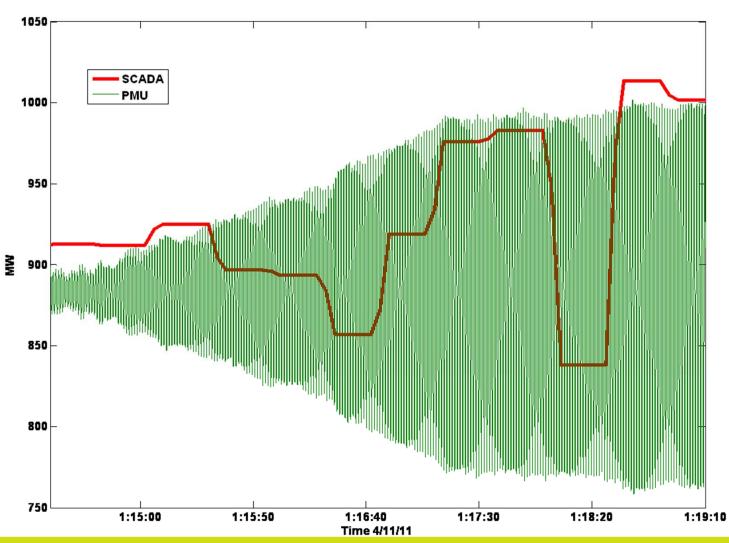






SCADA vs. Synchrophasor

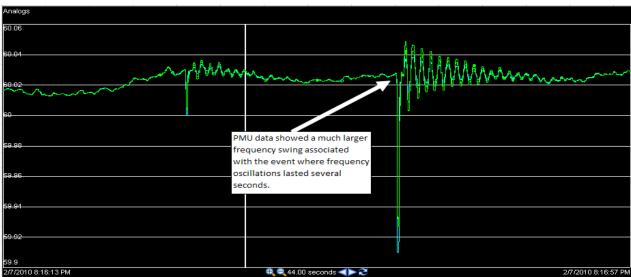




Value of Synchrophasor Technology



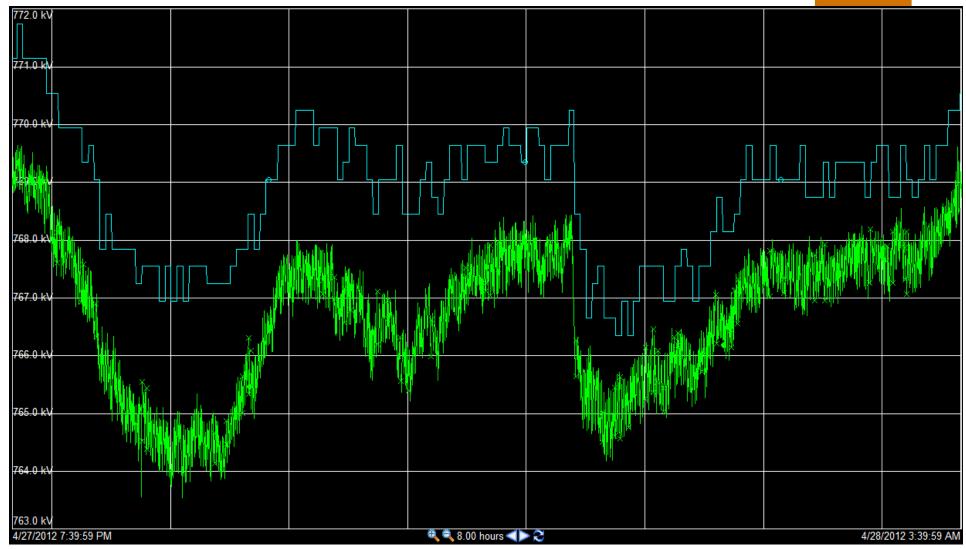




Phasor data provides granularity not possible in SCADA

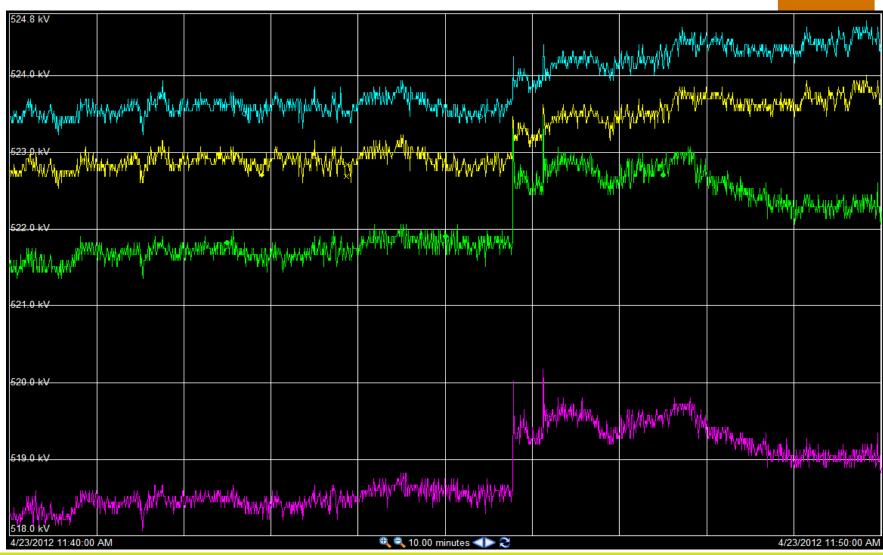
Phasor Data vs. SCADA Data – 765kv





500kv Voltages During Event





Synchrophasor for off-line Applications



- Forensic Event Analysis
- Oscillation and stability analysis
- Static system model calibration and validation
- Dynamic system model calibration and validation
- Generator & Load model calibration and validation
- System operating limits evaluation and design

Synchrophasor for on-line Applications



- Wide-area situational awareness
- Stability, oscillations and voltage monitoring
- Alarming
- Dynamic line ratings and congestion management
- System Restoration

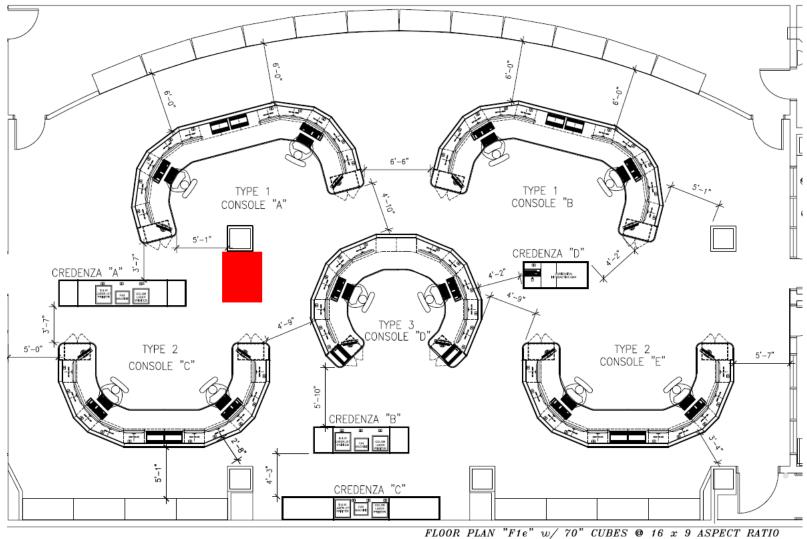
Control Room Displays



- Voltages
- Frequency
- Generation (steam, CTs, wind and hydro, etc.)
- Loads
- Tielines between transmission companies
- Oneline area overviews
- MW Reserves

Control Room Layout





Generation Dispatcher Wall – Detail Shot





Picture Tour – Far Left





Picture Tour – Generation and Transmission





Picture Tour – Left Middle





Picture Tour – Center





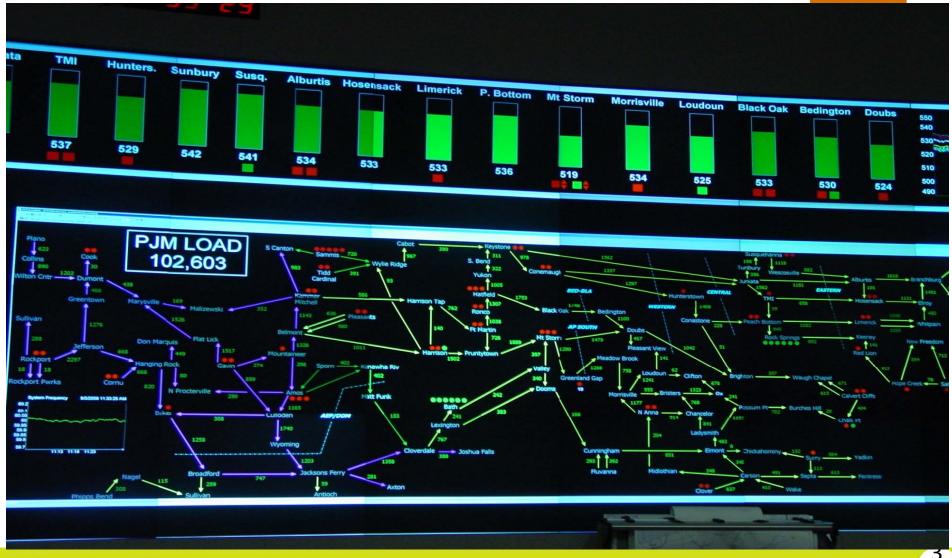
Picture Tour – Far Right





Picture Tour – Detail Shot





C2: Front Video Wall (Gen. and Trans.)





C2: Rear Video Wall (RE and MC)





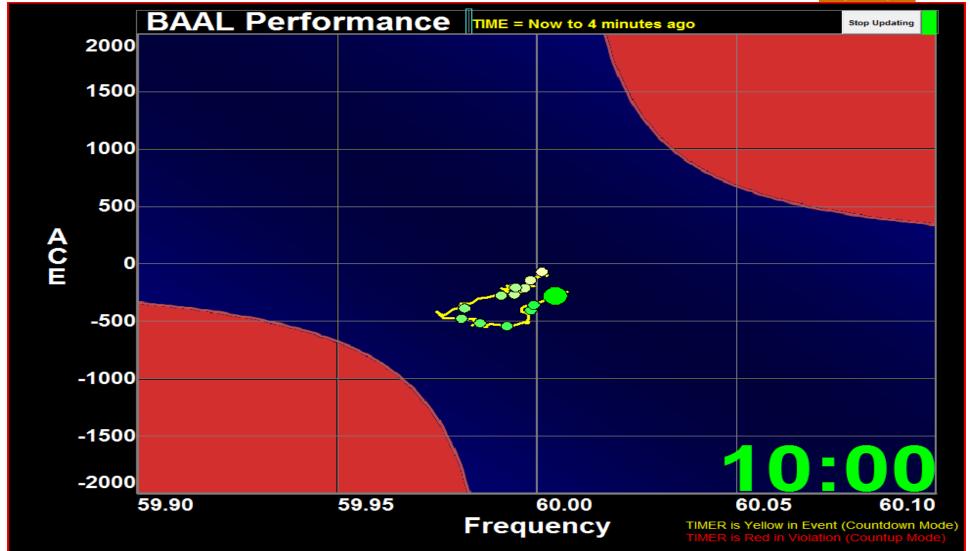
C2: Picture Tour



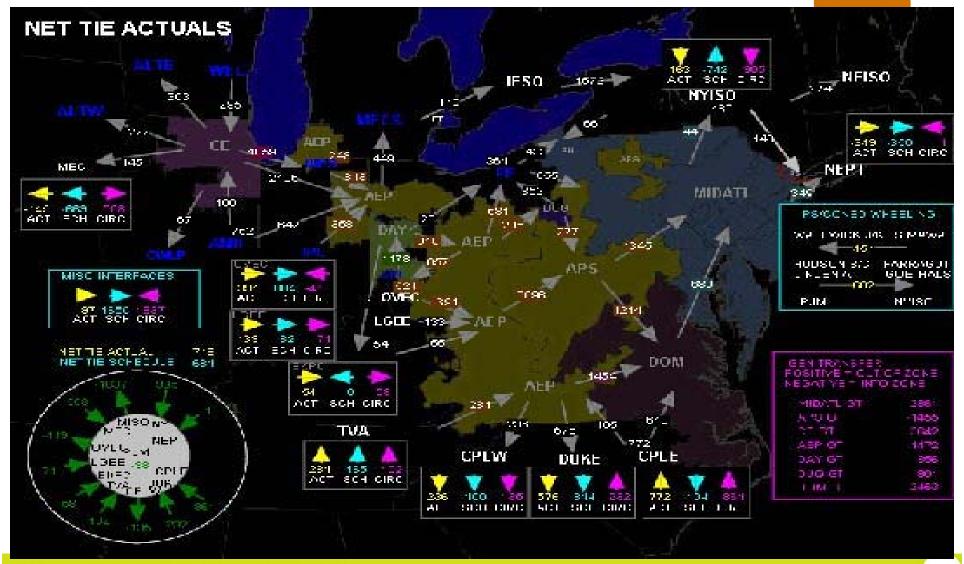


Balancing Authority ACE Limit (Area Control Error)



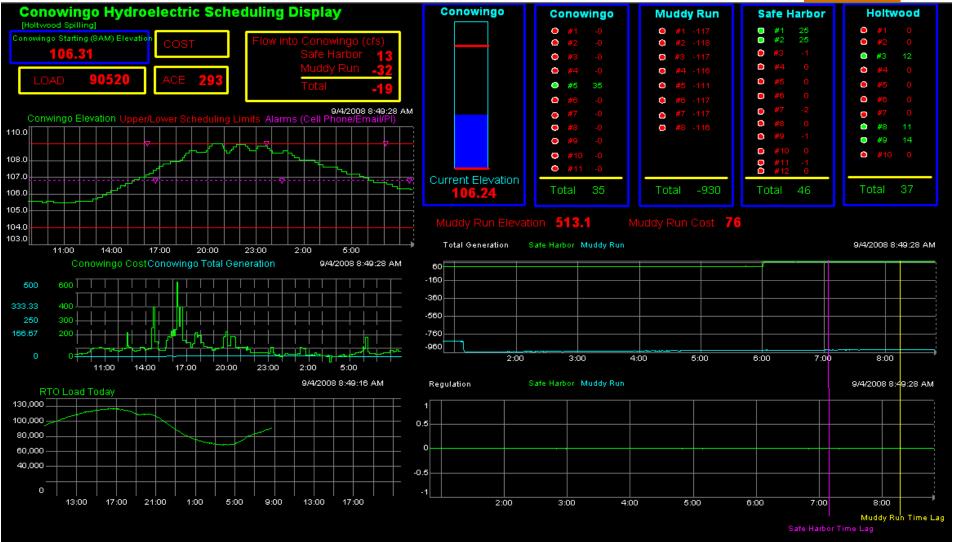


Internal and External Tie Line Flows



Hydro Generation Scheduling





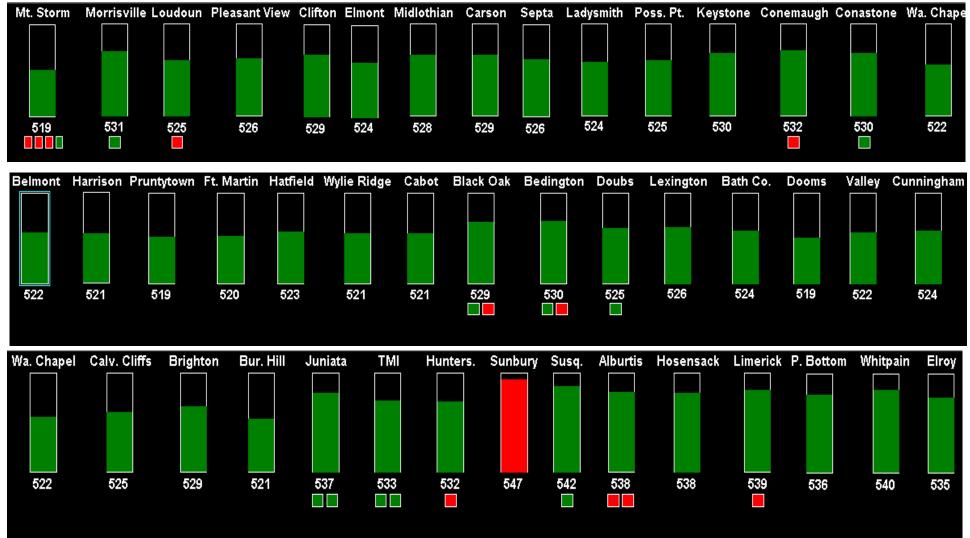
RTO Overview for FERC





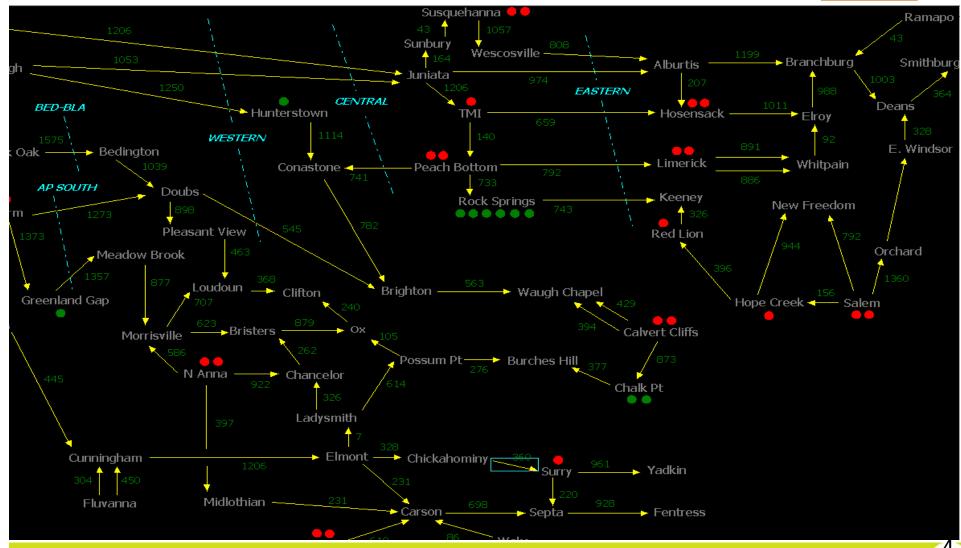
Transmission Bus Voltage





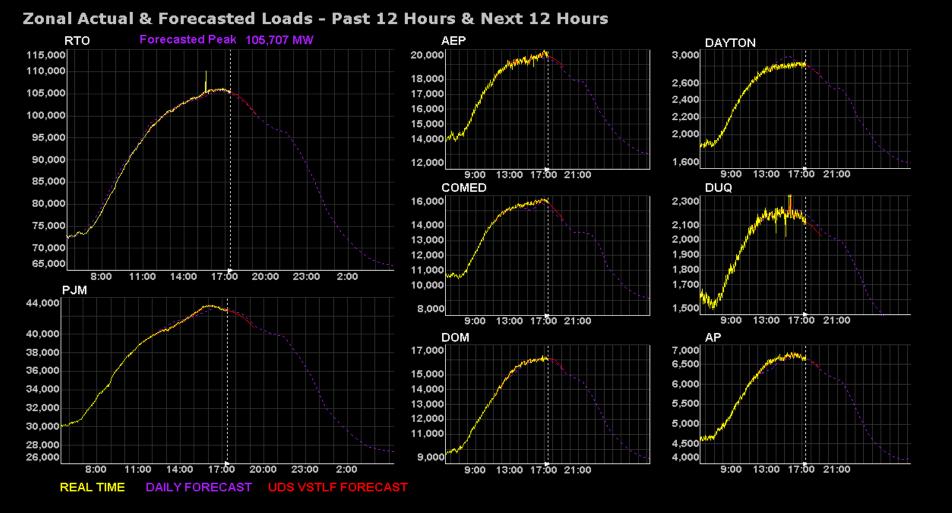
EHV Transmission Map





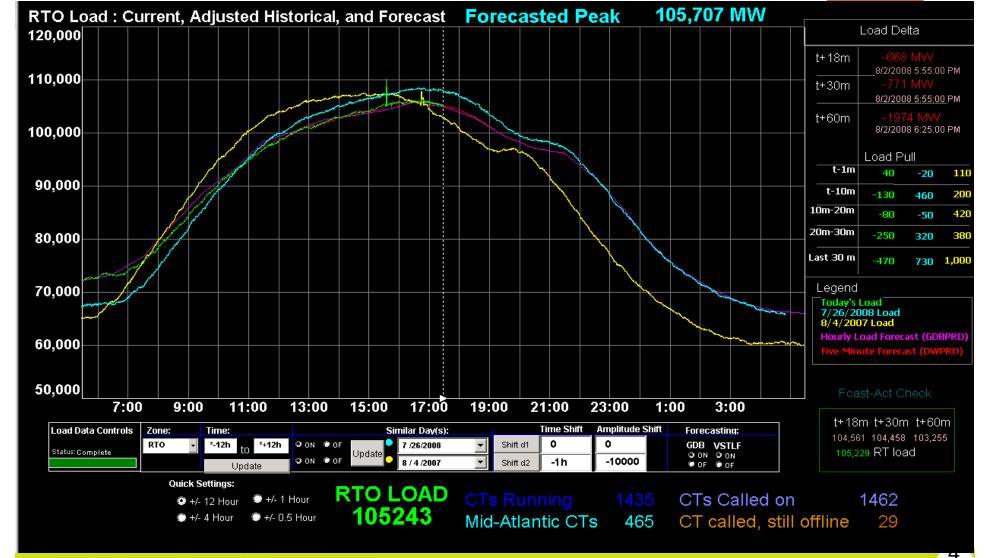
Actual & Forecasted Loads





Loading Profile: Historical, Current Adjusted and Forecast



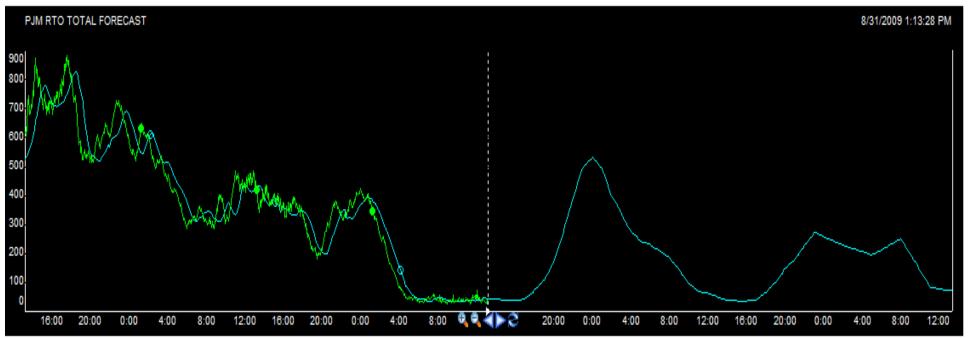


Load Forecasting



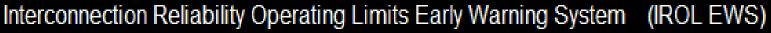
Load Forecast Data

- -Overlay of historical data and old forecast provides visual cues on tracking
- -Future data is seamlessly combined with historical and real-time data



Interconnection Reliability Operations Limits **Early Warning System**







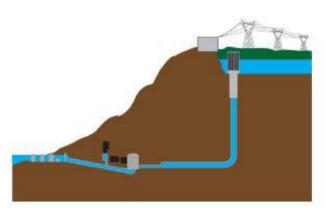
Data Shared with FERC/NERC



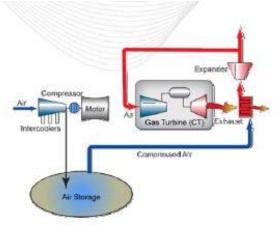


Smart Grid Innovation (Energy Storage in PJM)





Pumped Hydro



Compressed Air



Flywheels



Stationary Battery



Mobile Batteries



Water Heaters

Smart Grid and Plug-in Hybrid Electric Vehicles (PHEVs)





- Mid-Atlantic Grid

 Interactive Car

 Consortium (MAGICC)

 electric companies,

 research institutes, and vehicle manufacturers
- Over one year
 experience with the
 MAGICC battery
 electric vehicle
 responding to the PJM
 regulation signal

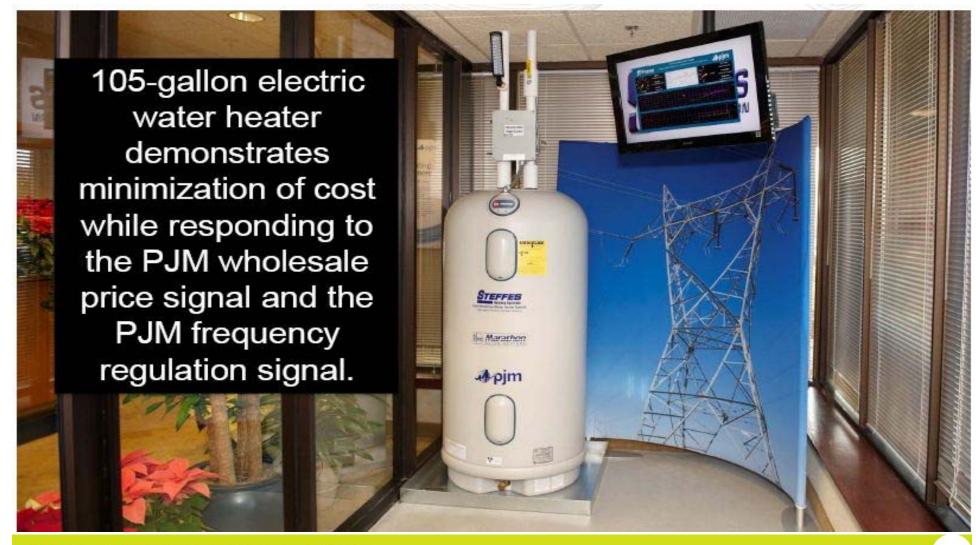
Smart Grid AES Grid-Scale Energy Storage System





Water Heater





Water Heater – Optimization of LMP and Frequency Regulation



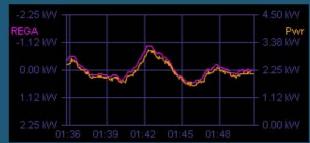


Grid Interactive Heater Control

Enhance reliability, Reduce cost, and Protect the Environment for Everyone

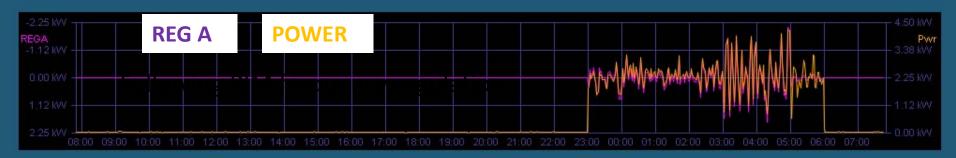






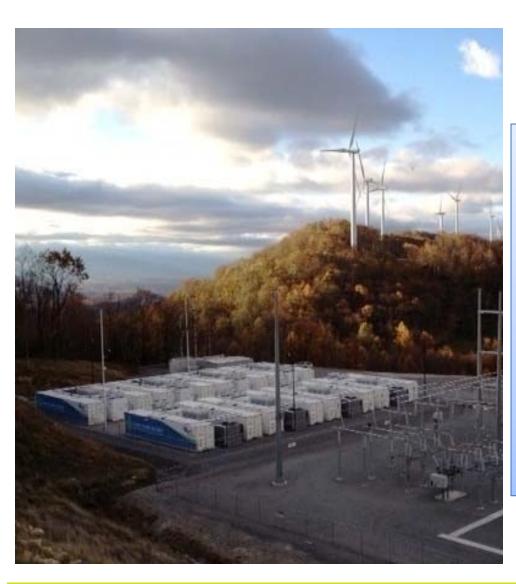






Grid-Scale Energy Storage System – 32 MW Battery





Laurel Mountain

Wind Farm

98 MW

61 turbines

Battery Storage

Lithium-ion (A123)

Power 32 MW

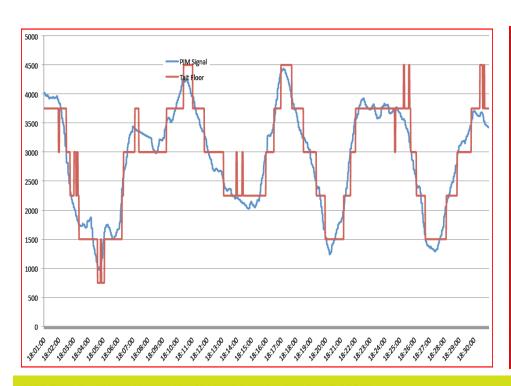
Energy 8 MWh

Electric Thermal Storage: Space Heaters



Vcharge Inc. controlling ETS units in 30 homes Stroudsburg, PA

Could save each household 6 – 9 cents/kWh if controlled for energy purchasing and Regulation





Rail Transportation: SEPTA Integrated Battery Storage

SEPTA: Southeastern PA Transportation Agency

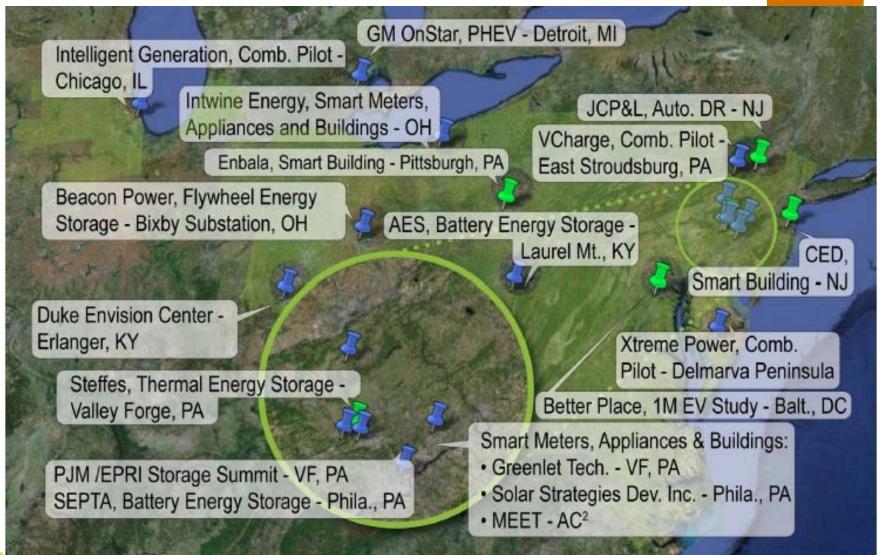
-Installed advanced battery storage system to recapture and deploy power from trains' regenerative braking



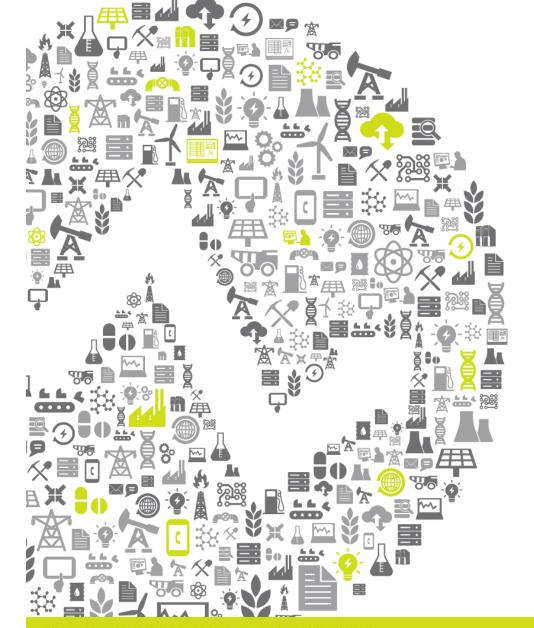


Innovation Activity









THANK

